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(54) **A bond or overlay MCrAlY-coating**

(57) It is disclosed a bond or overlay MCrAlY-coating for the use within a high temperature environment for the protection of the base alloy of turbine blades and vanes. The MCrAlY-coating having a  $\gamma$  or  $\gamma/\gamma'$ -structure comprises a dispersion of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. This provides a reservoir of aluminum reservoir

to coatings wherein the reservoir replenish the aluminum lost due to oxidation and interdiffusion during service. The  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY is the aluminum reservoir and is applied by mixing appropriate powders with  $\gamma$  or  $\gamma/\gamma'$  powders.

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## Description

## FIELD OF INVENTION

[0001] The invention relates to a bond or overlay MCrAlY-coating according to the preamble of claim 1.

## STATE OF THE ART

[0002] Components designed for the use in the area of high temperature, e.g. blades or vanes of a gas turbine, are usually coated with resistant coatings. The coating protects the base material against corrosion and oxidation due to the thermal effect of the hot environment and consists of an alloy mostly using the elements Al and Cr. Most turbine components are coated for protection from oxidation and/or corrosion with, for example, a MCrAlY coating (base coat) and some are also coated with a thermal barrier coating (TBC) for thermal insulation. MCrAlY protective overlay coatings are widely known in the prior art. They are a family of high temperature coatings, wherein M is selected from one or a combination of iron, nickel and cobalt. As an example US-A-3,528,861 or US-A-4,585,418 are disclosing such kind of oxidation resistant coatings. US-A-4,152,223 as well discloses such method of coating and the coating itself. Besides the  $\gamma/\beta$ -MCrAlY-coating, there is another class of overlay MCrAlY coatings which are based on a  $\gamma/\gamma'$ -gamma/gamma prime-structure. The advantages of  $\gamma/\gamma'$ -coatings is that they have a negligible thermal expansion mismatch with alloy of the underlying turbine article. For higher thermal fatigue resistance the  $\gamma/\gamma'$ -coating are more convenient compared to the  $\gamma/\beta$ -type of MCrAlY-coatings. A higher thermal fatigue resistance in coatings is most desirable since failure of the most turbine blades and vanes at elevated temperature is typically thermal fatigue driven.

[0003] Among  $\gamma/\gamma'$ -coatings and  $\gamma/\beta$ -coatings, the field of  $\gamma/\beta$ -coatings have been an active area of research and a series of patents has been issued. E.g. a Ni-CrAlY coating is described in US-3,754,903 and a CoCrAlY coating in US3,676,058. US 4,346,137 disclose an improved high temperature fatigue resistance NiCoCrAlY coating. US-4,419,416, US-A-4,585,481, RE-32,121 and US-A-4,743,514 describe MCrAlY coatings containing Si and Hf. US-A-4,313,760 discloses a superalloy coating composition with good oxidation, corrosion and fatigue resistance.

[0004] In contrast to the  $\gamma/\beta$ -coatings, the  $\gamma/\gamma'$ -type of MCrAlY coatings, known e.g. from US-A-4,973,445, are relatively new. The unique feature of this type of  $\gamma/\gamma'$ -coatings is that their thermal expansion mismatch is close to zero in combination with a high ductility, what make these coatings more resistant to thermal fatigue. However the limitations are the low aluminum content and hence their low reservoir of aluminum.

[0005] Furthermore, in the state of the art Thermal-Barrier-Coatings (TBC) are known from different patents. US-A-4,055,705, US-A-4,248,940, US-A-4,321,311 or US-A-4,676,994 disclose a TBC-coating for the use in the turbine blades and vanes. The ceramics used are yttria stabilized zirconia and applied by plasma spray (US-A-4,055,705, US-A-4,248,940) or by electron beam process (US-A-4,321,311, US-A-4,676,994) on top of the MCrAlY bond coat.

## SUMMARY OF THE INVENTION

[0006] It is object of the present invention to replenish the loss of aluminum by oxidation and interdiffusion in service due to long term exposure at elevated temperatures of a bond or overlay MCrAlY-coating having a  $\gamma$ - or  $\gamma/\gamma'$ -structure. Another object is to provide a durable coating for industrial and aircraft gas turbine engines.

[0007] According to the invention a bond or overlay MCrAlY-coating of an article was found, the coating having a  $\gamma$ - or  $\gamma/\gamma'$ -structure, the article used in a high temperature environment, wherein the MCrAlY-coating comprises a dispersion of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles.

[0008] The present invention provides an aluminum  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY reservoir to a  $\gamma$ - or  $\gamma/\gamma'$  alloy matrix by a dispersion of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. The  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles are applied by mixing a NiAl powder with a  $\gamma$ - or  $\gamma/\gamma'$  powder.

[0009] The powder size of the  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles for the mentioned broad range is from 5 to 150  $\mu\text{m}$ , but is preferably between of 20 to 75  $\mu\text{m}$ . The volume fraction of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY can be (vol.-%) 0.01 to 40%, preferably 0.01 to 25% and most preferably (vol.-%) 0.01 - 5%.

[0010] Preferably, the coating comprises at least one layer of a  $\gamma$ - or  $\gamma/\gamma'$ -structure containing the dispersed of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. This could be in alternating layers with and without the dispersed of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles or as a first layer on top of the gas turbine article and a layer on top of the coating. The dispersed  $\beta$ -NiAl particles will include (wt.-%) 20 - 33% Al and the  $\gamma/\beta$ -MCrAlY particles will include (wt.-%) 8 to 17% Al. Both can comprise one or a combination of Y, Hf, Zr, Si, Ca, Mg, Fe and Ta.

[0011] The coating can be applied by a galvanic or plasma spray or any other conventional method used for deposition of overlay and bond coatings.

## DETAILED DESCRIPTION OF INVENTION

**[0012]** It is disclosed a bond or overlay MCrAlY-coating for the use within a high temperature environment for the protection of the base alloy such as turbine blades or vanes. The MCrAlY-coating having a  $\gamma/\gamma'$ -structure comprises a dispersion of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. This provides an reservoir of aluminum reservoir to coatings wherein the reservoir replenish the aluminum lost due to oxidation and interdiffusion during service of the article. The  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY is the aluminum reservoir and is applied by mixing NiAl and/or  $\gamma/\beta$ -MCrAlY powders with a  $\gamma$  or  $\gamma/\gamma'$  powders.

**[0013]** The technical goal is to retain the ductility of the  $\gamma/\gamma'$  structure, and accrue the benefit of high aluminum containing dispersoid  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY which will provide sufficient Al to allow and retain formation of alumina scale. It is to be noted that due to higher ductility the  $\gamma/\gamma'$  matrix will accommodate the stresses generated during thermal mechanical loading of the component in service.

**[0014]** The bond or overlay MCrAlY-coating could consist of (wt.-%) 5-30% Cr and 3-6% Al, balance Ni, Fe or Co individually or in combination thereof, e.g. Ni-25Cr-3Al, Ni-25Cr-5Al or Ni-28Cr-6Al. The composition of the  $\gamma$  matrix is controlled by the phase diagram of nickel-chromium-aluminum ternary. The Ni, Cr, Al content of the MCrAlY is adjusted to allow the formation of stable  $\gamma/\gamma'$  microstructure.

**[0015]** Furthermore, the coating can comprise W, Re, Ru and Ta individually or in combination thereof. In addition, the coating could comprise one or a combination of Y, Hf, Zr and Si with (wt.-%) 0.1 - 5% Y+Hf+Zr+Si and one or a combination of Ta, Fe, Ga, Mg and Ca. A content according to this embodiment is (wt.-%) 0.001 - 0.5% Y, 0 - 0.5% Zr, 0.1 - 1.5% Si, 0 - 1.0% Ca, 0 - 1.0% Mg, 0 - 4% Ga, 0 - 4% Fe, 0.1 - 4.0% Ta.

**[0016]** Examples (wt.-%) for the coating compositions according to the invention are given in table 1 below.

Tab. 1

Example	Ni	Co	Cr	Al	Hf	Y	Ta	Si	$\beta$ -NiAl and/or $\gamma/\beta$ -MCrAlY (vol.-%)
I	Bal.	--	25	5	0.5	0.2	--	--	5
II	Bal.	28	12	7	--	0.05	0.5	1.2	2
III	Bal.	25	25	6	0.5	0.2	--	--	10
IV	Bal.	--	12	7	--	0.3	--	--	20
V	Bal.	25	25	5	--	0.3	--	1.2	15
VI	Bal.	--	25	5	0.5	0.2	--	--	1
VII	Bal.	--	17	5	0.5	0.2	--	--	5
VIII	Bal.	--	25	5	0.5	0.2	--	--	0.5

**[0017]** The volume fraction of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles could be between (vol.-%) 0.01 to 40%. A preferred range is between (vol.-%) 0.01 and 25%, a most preferred range is between (vol.-%) 0.01 and 5%. The powder size of the  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY is within the broad range up to 125  $\mu$ m, but generally limited to 20 to 75  $\mu$ m.

**[0018]** This invention provides lifetime benefits by retaining the alumina forming capability of the coating due to  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particulate dispersion in the coating matrix as typical for  $\gamma/\beta$ -MCrAlY coatings.

**[0019]** The dispersed  $\beta$ -NiAl particles can include (wt.-%) 20 - 33% Al and the  $\gamma/\beta$ -MCrAlY particles will include (wt.-%) 8 to 17% Al. Both can comprise and one or a combination of Y, Hf, Zr, Si, Ca, Mg, Fe and Ta, which increases the oxidation resistance further. As an example the  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles can comprise (wt.-%) 0.001 - 0.5% Y, 0.001 - 0.5% Zr, 0.1 - 1.5% Si, 0 - 1.0% Ca, 0 - 1.0% Mg, 0 - 4% Ga, 0 - 4% Fe, 0.1 - 4.0% Ta.

**[0020]** Preferably, the coating comprises at least one layer of a  $\gamma$ - or  $\gamma/\gamma'$ -structure containing the dispersed of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. This could be in alternating layers with and without the dispersed of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles. This could be as well as a first layer on top of the gas turbine article and a layer on the outer surface of the coating.

**[0021]** The coating can be applied by a galvanic or plasma spray or any other conventional method used for deposition of overlay and bond coatings.

## Claims

1. A bond or overlay MCrAlY-coating on the surface of an article, the MCrAlY-coating having a  $\gamma$ - or  $\gamma/\gamma'$ -structure, wherein the MCrAlY-coating comprises a dispersion of  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles.

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2. The bond or overlay MCrAlY-coating according to claim 1, comprising a powder size of the  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles from 5 to 150  $\mu\text{m}$ .
3. The bond or overlay MCrAlY-coating according to claim 2, comprising a powder size of the  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles of 20 to 75  $\mu\text{m}$ .
4. The bond or overlay MCrAlY-coating according to any of the claims 1 to 3, wherein the coating comprises at least one layer of a  $\gamma$ - or  $\gamma/\gamma$ -structure containing the dispersed  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles.
5. The bond or overlay MCrAlY-coating according to claim 4, wherein the coating consists of alternating layers with and without the dispersed  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles.
6. The bond or overlay MCrAlY-coating according to claim 4, wherein a first layer on top of the article and a top layer containing the  $\gamma$ - or  $\gamma/\gamma$ -structure with the dispersed  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles.
7. The bond or overlay MCrAlY-coating according to any of the claims 1 to 6, comprising a volume fraction of (vol.-%) 0.01 to 40%  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY.
8. The bond or overlay MCrAlY-coating according to claim 7, comprising a volume fraction of (vol.-%) 0.01 to 25%  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY.
9. The bond or overlay MCrAlY-coating according to claim 8, comprising a volume fraction of (vol.-%) 0.01 to 5%  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY.
10. The bond or overlay MCrAlY-coating according to any of the claims 1 to 6, wherein dispersed  $\beta$ -NiAl particles include (wt.-%) 20 - 33% Al.
11. The bond or overlay MCrAlY-coating according to any of the claims 1 to 6, wherein dispersed  $\gamma/\beta$ -MCrAlY particles include (wt.-%) 8 to 17% Al.
12. The bond or overlay MCrAlY-coating according to any of the claims 1 to 6, wherein the dispersed  $\beta$ -NiAl and/or  $\gamma/\beta$ -MCrAlY particles contain one or a combination of Y, Hf, Zr, Si, Ca, Mg, Fe and Ta.
13. The bond or overlay MCrAlY-coating according to any of the claim 1 to 6, wherein the MCrAlY-coating is deposited by a galvanic or plasma spray or any other conventional method.



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## EUROPEAN SEARCH REPORT

Application Number  
EP 02 40 5010

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	<p>GUDMUNDSSON B ET AL: "Structure formation and interdiffusion in vacuum plasma sprayed CoNiCrAlY coatings on IN738LC" MATERIAL SCIENCE AND ENGINEERING, APRIL 1988, SWITZERLAND, vol. 100, pages 207-217, XP008007727 ISSN: 0025-5416</p> <p>* page 9, Experimental *</p>	1,10,13	<p>C23C30/00 C22C19/05 C23C28/02</p>
X	<p>EP 1 061 150 A (ABB ALSTOM POWER CH AG) 20 December 2000 (2000-12-20)</p> <p>* claims 1,3,11,12 *</p>	1,7,8,10	
X	<p>TOMA D ET AL: "STUDIES ON THE TRANSIENT STAGE OF OXIDATION OF VPS AND HVOF SPRAYEDMCRAZY COATINGS" SURFACE AND COATINGS TECHNOLOGY, ELSEVIER, AMSTERDAM, NL, vol. 120/121, 1999, pages 8-15, XP001004808 ISSN: 0257-8972</p> <p>* page 9, right-hand column *</p>	1,4,6,12,13	
			<p>TECHNICAL FIELDS SEARCHED (Int.Cl.7)</p> <p>C23C C22C</p>
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		4 September 2002	Patterson, A
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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